



Enhancing Grid Infrastructures with  
Virtualization and Cloud Technologies

## **Exploitation and Sustainability Final Plan**

Deliverable D3.5 (V1.3)  
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### **Abstract**

This document describes StratusLab's plans for exploitation and sustainability beyond the project lifetime. The plans cover commercial exploitation, primarily through commercial integration and support; and non-commercial exploitation, through use in national and international research e-infrastructures: for operating grid resources on private clouds, and for running research-oriented community clouds. In addition, we plan exploitation through partner projects such as EGI and through training and future research. Plans are in place to ensure the sustainability of the critical infrastructures used by the project partners, users and collaborating projects. Similarly, the software outputs of the project have been identified and a plan for the future development of each has been created. These plans include the formation of an open-source StratusLab community, identifying key partners to continue development of specific components, identifying funding options (public, private and community contributions) for continued development and engaging with collaborating projects to ensure that they will contribute to the maintenance and development of the components that they use.



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# 1 Executive Summary

This document describes the plans to exploit the project results and to ensure their sustainability beyond the project lifetime.

The plans cover both commercial and non-commercial exploitation. Commercial exploitation will take the form of integration and support: several specific examples related to project partners are described, including SixSq and SlipStream, and the Telefónica I+D Global Cloud Initiative.

Non-commercial exploitation will include use of StratusLab within national and international research e-Infrastructures: private clouds for service deployment – particularly for grid services – as well as public clouds for research communities. For systems administrators, StratusLab will provide a convenient approach for testbed deployment.

OpenNebula, as well as providing a core component of the StratusLab software, offers a key point of exploitation, as StratusLab-originated innovations are provided to its user community.

Collaborating projects, particularly from the Distributed Computing Infrastructure sphere, will provide another channel of exploitation.

Finally, StratusLab project results will be exploited to provide opportunities for future cloud research, and for training and e-Learning.

With respect to sustainability, the project has concrete plans in place for sustainability after the project lifetime, including continuation of critical infrastructure, continued development of software components as well as future research.

Some future funding, from both public and private sources, has been secured to continue development and research of specific components of the StratusLab Distribution. The overall plan for sustainability, however, involves the creation of an open-source consortium under which development and maintenance will be ensured by the strong involvement of the existing project partners, along with fostering an open-source community among users.

## **2 Introduction**

Cloud computing is revolutionising the way we procure and consume computing, storage and networking resources, as well as the way these resources are managed at the infrastructure level. StratusLab offers an open source cloud distribution, targeted particularly at the e-science community.

### **2.1 Purpose**

This document updates the Deliverable D3.3 “Exploitation and Sustainability First Plan”[11] and outlines the final exploitation and sustainability plan for the StratusLab project. This document describes the plans to exploit the project results and to ensure the sustainability of the products beyond the project lifetime.

### **2.2 Organization**

This document contains chapters on Exploitation and Sustainability and finishes with Conclusions. The Exploitation and Sustainability chapters draw on plans provided by each partner and the Conclusions include a summary of exploitation and sustainability strategies that cut across the project as a whole.

## 3 Exploitation

This section describes the current exploitation of the StratusLab project's outputs, in line with the initial plans laid out in D3.3. It also includes a number of exploitation activities that are expected to continue beyond the project lifetime, including those by project partners as well as external entities.

The project hopes that its work will be rewarded by a wide adoption by grid sites and infrastructure providers around Europe and beyond our frontiers. This exploitation should also generate feedback and requests for further improvements. Further, as the distribution is deployed and used, a larger set of virtual machines and datasets will be produced and maintained using StratusLab software.

The project has engaged with user communities and other FP7 projects in order to ensure that the software and other outputs of the project are utilised. Over the lifetime of the project 47 users have requested accounts on the StratusLab reference infrastructure in order to try out the cloud distribution and many more have downloaded the software themselves. The project Deliverable "Final Review of Dissemination, Collaboration and Standardization Activities" (D3.4)[14] gives more detail on the project's outreach and collaboration activities as well as some of the statistics on usage of the StratusLab reference infrastructure and software. Several communities are currently using or evaluating the StratusLab Distribution or components thereof. Similarly, through efforts of the project partners, a number of new commercial products based on the StratusLab Distribution have been developed.

Exploitation of the project results falls into four broad categories; commercial exploitation, exploitation by e-Infrastructures and user communities, use of the StratusLab distribution and other outcomes of the project such as expertise and know-how in future research projects, and use in training infrastructures.

### 3.1 Commercial exploitation

Commercial exploitation of project results comes in several forms, including integration with commercial products and commercial support work.

#### 3.1.1 DS-Cloud Ready Pack

Partner SixSq has developed a commercial cloud solution in collaboration with Swiss IT Solutions provider Darest. The product, announced in March 2012, is a turnkey Infrastructure as a Service (IaaS) cloud solution, based on the StratusLab



Distribution along with SixSq's SlipStream.

The product targets small and medium enterprises looking for a private cloud solution, and includes managed services such as a public StratusLab Marketplace and SlipStream services, providing users with virtual images and appliances, as well as construction and deployment recipes.

The DS-Cloud Ready Pack will be distributed by Darest.

### **3.1.2 StratusLab Certification on IBM PureSystems**

SixSq has also tested and certified the StratusLab software on IBM PureSystems hardware. IBM PureSystems is at the higher end of the cloud market and this initiative ensures that StratusLab is an option for larger cloud deployments.

### **3.1.3 Helix Nebula Consultancy**

SixSq is building consultancy based on the StratusLab distribution. For example, in the context of the Helix Nebula collaboration, SixSq and Atos (one of the Helix Nebula cloud suppliers) are working together building a commercial public cloud proof of concept. This proof of concept is being evaluated by CERN, EMBL and ESA.

### **3.1.4 ESOC-ESA**

SixSq has developed a proof-of-concept to show rapid deployment of ground-control systems for the European Space Agency's European Space Operations Centre (ESOC). This was done as a demonstration running on an infrastructure belonging to Terma, the company who produce the software used by ESOC. The proof-of-concept showed that the deployment time could be reduced from approximately 1 week to less than 10 minutes. SixSq are now working with Terma and ESOC to deploy a similar configuration within ESOC for their production ground-control systems. The three are looking for sources of funding to continue this work.

### **3.1.5 SlipStream**

SixSq's flagship SlipStream product is an automated engine for creating multi-machine runtime environments, using cloud computing as a back-end. While initially deployed using the Amazon EC2 cloud service as the cloud back-end, SixSq have integrated support for StratusLab clouds. This has opened up SlipStream for potential use by a significant number of companies who are unable to use Amazon EC2 cloud due to reasons ranging from legal to cultural. The commercial activities mentioned above use Slipstream running on StratusLab, and SixSq are confident that they will be able to attract many more customers by leveraging the combination of these two products.

### **3.1.6 Telefónica I+D Global Cloud Initiative**

As described in D3.3 Telefónica I+D (TID) works on research and development activities and provides new and innovative products and solutions which can be

commercialized by Telefónica's operators (LATAM, Spain, O2 Europe, etc.).

In the context of the 2009–2012 Strategic Plan, Telefónica I+D has established the Cloud Computing Area where an IaaS Cloud Product Line is under development. The TID main objective is to provide advanced capabilities for Cloud products to be part of their roadmaps. Telefónica cloud products worth particular mention include the Virtual Data Center, a public Cloud for big companies [8] or the private Cloud developed for a Spanish regional government [1].

Within the StratusLab project, TID has been working on the service manager Claudia, as a added-value component on top of any Cloud platform, providing management of multi-tier applications and scalability according to the service KPIs. TID has been developing the KPI monitoring systems as a framework to collect KPIs from services to be used for scalability. Both Claudia and monitoring systems represent added-value prototypes for integration into TID Cloud initiatives, demonstrating new advanced functionalities going beyond current Cloud platforms such as Amazon EC2, OpenStack or Flexiscale. These components represent the seed of medium-term work on the public or private Cloud platforms, and are the proof of concept of advanced use cases.

### **3.1.7 Advanced service management and scalability prototype**

Partner Telefónica I+D has developed the prototype multi-tier e-Business application as a proof of concept demonstrating multi-tier service management, KPI-driven scalability, load balancing, monitoring, secure networking and cloud federation. This proof of concept demonstrates the advanced Cloud capabilities that a Cloud platform can provide. Currently, Cloud providers only offer VM deployment, but with StratusLab's advanced capabilities as demonstrated by this multi-tier application use case, it is possible to show how an organisation can provision of e-business applications (mainly composed by front-end, business-logic and database), automatically scale them based on service KPIs (not hardware KPIs as most providers allow), ensure security in the network and offer federation among sites.

The prototype might also be used by other StratusLab partners to show the advantages of using these advanced features that StratusLab provides.

### **3.1.8 UCM and C12G Labs consultancy**

As a University research group, UCM's aim is to perform applied research and to transfer the results to the industry and the scientific community. So, although their primary aim is not to commercially exploit the results, UCM offers value-added services around OpenNebula through the University Office of Technology Transfer.

UCM and their spin-off company C12G Labs provide support for OpenNebula, a core component of StratusLab. They are already seeing support requests from StratusLab users via the OpenNebula support channels. Thus the StratusLab community is now supported by UCM alongside other communities using OpenNebula without the StratusLab distribution. UCM and C12G Labs are committed to pro-

viding ongoing support for these users, in line with their existing support policies. This includes supporting those StratusLab extensions to OpenNebula which have subsequently been merged back into the OpenNebula product.

## **3.2 Exploitation in e-Infrastructures and user communities**

User communities – and in particular the community of research e-infrastructures – offer important opportunities for the exploitation of the StratusLab project results.

### **3.2.1 Computing sites**

Individual computing sites, initially those related to the project partners, are already seeing benefits from exploiting the StratusLab software locally.

#### **3.2.1.1 CNRS**

The CNRS laboratories involved in StratusLab are already exploiting the StratusLab software to provide services to system administrators, engineers, and scientists. Both LAL and IBCP plan to further their use of the StratusLab cloud technologies in the near future and are participating in planning at the national level to provide cloud services via existing and new generic computing infrastructures.

As described in D3.3 LAL has deployed both private and public StratusLab clouds. The private cloud infrastructure is used by developers and system administrators within LAL, while the public cloud infrastructure is available to external users who register for access to the service. Both of these services are in active use and will continue to be maintained beyond the project lifetime.

IBCP was already using virtualization heavily for the provision of local services and of grid services within EGI before the beginning of the StratusLab project. An initial goal of IBCP within the StratusLab project was to be able to quickly deploy grid-sites using StratusLab which were customised for the bioinformatics community. As the project progressed, however, it has become apparent that services can be more easily provided to the bioinformatics user community by using cloud directly. Thus, IBCP has created a number of bioinformatics appliances containing applications and databases for their users, and they run a StratusLab cloud which allows members of the French bioinformatics community to deploy these virtual appliances and perform their analysis directly on the cloud rather than using the grid. The StratusLab cloud provides services for this community which are not available elsewhere (e.g. via the grid) and so IBCP are committed to maintaining a StratusLab site for the foreseeable future.

Users of the infrastructure also require access to a Marketplace instance, and IBCP may install a federated Marketplace at a later stage in order to ensure that this service continues to be available to their users after the end of the StratusLab project.

IBCP continues to promote their StratusLab cloud infrastructure within the French Bioinformatics Institute and beyond.

Both laboratories have already benefited from their existing StratusLab deployments through the better use of existing hardware and improved (easier, faster, and more flexible) provisioning of resources to administrators and users. These improvements have positively impacted both general laboratory services and scientific analyses.

#### **3.2.1.2 TCD**

As described in Deliverable D3.3, TCD already makes use of StratusLab as a testbed platform. This is used for testing new releases of software, new grid and other services, and to perform initial installation of hardware before it is integrated into production at TCD or at other Grid-Ireland sites. TCD plans to convert some grid resources to run on a StratusLab cloud in the future, this may be as part of EGI with production grid services within the Grid-Ireland infrastructure running on top of StratusLab.

As a grid resource provider and Computer Science research group, TCD has begun to use StratusLab in a number of research contexts, for example, StratusLab has been investigated as a platform for providing virtualized access to GP-GPU grid worker nodes. This work was presented at the EGI Community Forum 2012 and may be taken up in time by other site operators as a solution to the problem of providing access to GPU resources.

TCD is likely to continue to use StratusLab as their cloud distribution of choice for such research initiatives and projects.

### **3.2.2 National infrastructures**

#### **3.2.2.1 France**

There is a growing realization in CNRS and in France that cloud services provide a more flexible and dynamic computing infrastructure than is currently available with existing infrastructures. Taking more advantage of these technologies would allow the infrastructure to appeal to a wider scientific community and thus allow consolidation and better use of computing and human resources. Consequently, France-Grilles, the French partner of EGI and RENABI GRISBI, the French distributed bioinformatics infrastructure, both are investigating use of StratusLab and providing cloud-like services to their user communities. These investigations also include studies of possible national funding models while taking advantage of the administrative and support services which already exist within France-Grilles and RENABI GRISBI.

The support of a Quattor-based installation for StratusLab also makes it easier for the majority of sites in France-Grilles, who use Quattor, to adopt the StratusLab cloud distribution. Wider use makes it easier to justify the necessary human resources to maintain and to evolve the CNRS components of the distribution after the end of StratusLab.

### **3.2.2.2 Greece**

GRNET plans to continue developing a Greek cloud infrastructure, however, this will be based on the Okeanos IaaS platform. GRNET will continue to run their existing StratusLab-based Grid site, as well as exploiting the know-how and expertise produced by the StratusLab project in the context of the Okeanos project, which may reuse parts of the StratusLab Distribution.

### **3.2.2.3 Ireland**

TCD anticipates that the cloud approach offered by StratusLab may be attractive to potential resource providers and users for whom grid computing did not appear suitable.

As a grid operations centre with responsibility for maintaining Grid-Ireland, the Irish national grid infrastructure, TCD is already an intensive user of virtualization technology for testing and deployment. At a high level, TCD will exploit StratusLab to provide a simpler private cloud approach for server deployment.

TCD runs a set of Xen hosts for national services, but VMs are statically allocated. TCD plans to use of StratusLab to simplify the deployment of these services. TCD currently deploys grid gateways to Grid-Ireland sites around Ireland. Each gateway hosts a number of Xen virtual machines for various grid services. TCD will evaluate the use of StratusLab to deploy these systems in future.

## **3.3 Research Exploitation & Collaborating Projects**

The StratusLab partners are involved in several other EU and nationally-funded projects which will continue to exploit the outputs of the project. In addition, the project has pursued collaborations with other projects, and disseminated the project results widely to ensure that the outputs of the project will be exploited by many other research projects going forward.

### **3.3.1 The OpenNebula Community**

As a core component of the StratusLab distribution, UCM is extending the OpenNebula open-source toolkit to address the requirements of the Grid computing community that have been identified in the project. These extensions are incorporated into the main OpenNebula distribution and so they are available for all users of the toolkit and not only for the users of the StratusLab distribution.

OpenNebula serves as an excellent vehicle to transfer the technology and the innovation created in the project because it is used as a cloud management tool in thousands of deployments around the world and across different industries, such as hosting, telecoms, HPC, and eGovernment. Moreover OpenNebula is being used in many EU-funded projects as a tool for innovation and interoperability. This technology transfer is a valuable mechanism by which industry can accelerate its innovation activities and gain competitive advantage through cloud computing.

### 3.3.2 Collaborating Projects

The existing StratusLab infrastructures also enable exploitation and collaboration with other regional and European projects.

The European Grid Infrastructure (EGI) has expressed a clear interest in using virtualization technology. TCD, GRNET and CNRS participate in EGI and are likely to take part in the EGI transition to virtualized grid resources, based on StratusLab technology. As mentioned above, GRNET and CNRS have for some time run and evaluated StratusLab as a virtual platform for EGI grid sites with positive results. These experiences are documented in the project's Technical Note *Installing and operating a production grid site in the StratusLab cloud: Experience and issues*[10].

Within the context of the FP7 Mantychore project, TCD expects to deploy StratusLab-based computing resources to a number of Grid-Ireland sites as part of a use-case for next-generation dynamic networking. This will form the basis for research in network-level federation of cloud resources, resource migration, load distribution, and comparison with 'static' non-cloud grid resources.

StratusLab partners TID and UCM are involved in the 4CaaS project which aims to create an advanced PaaS Cloud platform supporting optimized and elastic hosting of Internet-scale multi-tier applications. The project will use Claudia and the Stratuslab monitoring systems as a key component of its Cloud platform, as well as OpenNebula and the StratusLab OpenNebula enhancements.

Another project where TID is evolving the Claudia service manager is FI-Ware PPP-Core. Their new requirements are coming which will allow them to evolve the component with new functionalities.

The Initiative for Globus in Europe (IGE) project has created a number of Globus virtual appliances which are available via the StratusLab Marketplace. These allow users to quickly deploy Globus infrastructures running over a StratusLab cloud.

The VENUS-C project uses OpenNebula and thus benefits from the outcomes of the StratusLab project, and the StratusLab enhancements to OpenNebula. This project is continuing research in the cloud area including work to support the DMTF OVF standard.

The BonFIRE consortium brings together world leading industrial and academic organisations in cloud computing to deliver a robust, reliable and sustainable facility for large scale experimentally-driven cloud research. The majority of their sites are running OpenNebula and thus benefiting from the StratusLab OpenNebula enhancements.

## 3.4 Training and e-Learning

TCD has a strong interest in e-Learning technology. StratusLab provides the ability not only to simplify management of a standing training infrastructure, but also to quickly deploy isolated infrastructures or to scale up existing ones to cope with the anticipated load of scheduled training events. StratusLab also will appear as a

subject of e-Learning material.

### **3.5 Summary**

The StratusLab Distribution has been integrated into several commercial products, and forms the basis for a number of new products. Some of these have already been officially launched while others in development, but with significant potential.

The software is also being used by many user communities and other projects within the e-Infrastructures area to provide infrastructures for their users. In addition collaborating projects are using the StratusLab Distribution and the other outputs of the project as part of their research.

Finally, exploitation areas such as testbeds and training infrastructures are being explored by the project partners.

The exploitation outcomes of the StratusLab project are summarised in Table 3.1.

**Table 3.1: Exploitation Outcomes**

Name	Description	Partner	StratusLab Results	Type	Target Market
DS-Cloud Ready Pack	Turnkey cloud solution using StratusLab and SlipStream	SixSq	StratusLab Distribution, project know-how	Commercial	Small and medium enterprises
IBM PureSystems	Certification of the StratusLab Distribution on IBM PureSystems high-end cloud hardware	SixSq	StratusLab Distribution, project know-how	Commercial	Large enterprises
Helix Nebula Consultancy	Use of the StratusLab distribution for the Helix Nebula Atos cloud infrastructure	SixSq	StratusLab Distribution, project know-how	Commercial	European researchers
ESOC-ESA	Rapid deployment system for ESOC ground-control software	SixSq	StratusLab Distribution, project know-how	Commercial	European Space Agency
SlipStream	SlipStream product for creating automated, on-demand, creation of multi-machine runtime environments, integrated with StratusLab	SixSq	StratusLab Distribution, project know-how	Commercial	Small, medium and large enterprises
Telefónica I+D Global Cloud Initiative	Use of StratusLab for a range of cloud products for commercialisation by Telefónica's operators	TID	Claudia, other components, project know-how	Commercial	Telecoms operators
Telefónica I+D service management & scalability prototype	A multi-tier e-Business application demonstrating advanced StratusLab features	TID	Claudia, other components, project know-how	Commercial	Telecoms operators, SMEs, larger enterprises
UCM and C12G Labs consultancy	Consultancy and support for OpenNebula StratusLab components	UCM	OpenNebula, StratusLab OpenNebula enhancements, project know-how	Commercial	OpenNebula users
					Continued on next page



Table 3.1 – continued from previous page

Name	Description	Partner	StratusLab Results	Type	Target Market
e-Infrastructures sites	Use of StratusLab to provide cloud services and grid over cloud to European researchers	CNRS, GRNET, TCD	StratusLab Distribution, project know-how	e-Infrastructures	International research communities
National e-Infrastructures	Use of StratusLab Distribution, or other project results in the provision of national cloud infrastructures	CNRS, GRNET, TCD	StratusLab Distribution, project know-how	e-Infrastructures	National research communities
French Bioinformatics Community	CNRS has provided Virtual Appliances for the French Bioinformatics community and maintains a cloud infrastructure for them	CNRS	StratusLab Distribution, project know-how	e-Infrastructures	National research communities
EGI Marketplace	EGI has deployed its own instance of the StratusLab Marketplace	TCD	StratusLab Marketplace, project know-how	e-Infrastructures	European e-Infrastructure providers and researchers
OpenNebula Community	Incorporation of StratusLab enhancements into OpenNebula and adoption by the existing OpenNebula community	UCM	OpenNebula, StratusLab OpenNebula enhancements, project know-how	Research & Collaborations	Existing OpenNebula users
EGI	EGI may adopt other components of the StratusLab Distribution, or they may be adopted by NGIs	All	StratusLab Distribution, project know-how	Research & Collaborations	European e-Infrastructure providers and researchers
Mantychore	The Mantychore project will use the StratusLab Distribution for their use-case for next-generation dynamic networking	TCD	StratusLab Distribution, project know-how	Research & Collaborations	European Researchers
					Continued on next page

Table 3.1 – continued from previous page

Name	Description	Partner	StratusLab Results	Type	Target Market
4CaaS	The 4CaaS project will use and further develop StratusLab components	TID, UCM	Claudia, OpenNebula, StratusLab OpenNebula enhancements, project know-how	Research & Collaborations	European Researchers
IGE	The IGE project maintains Globus virtual Appliances in the StratusLab Marketplace for their user communities	All	StratusLab Marketplace, StratusLab distribution and infrastructure, project know-how	Research & Collaborations	The Globus user community and e-Infrastructure providers
VENUS-C	The VENUS-C project uses the OpenNebula StratusLab component and the OpenNebula enhancements developed as part of the project	UCM	OpenNebula, StratusLab OpenNebula enhancements, project know-how	Research & Collaborations	Researchers
BonFIRE	The BonFIRE project uses the OpenNebula StratusLab component and the OpenNebula enhancements developed as part of the project	UCM	OpenNebula, StratusLab OpenNebula enhancements, project know-how	Research & Collaborations	Researchers
Training & eLearning	TCD will use the StratusLab Distribution for their training infrastructure	TCD	StratusLab Distribution, project know-how	Training	National and International Researchers

## 4 Sustainability

This section describes the plans that the project has put in place to ensure that the sustainability of the StratusLab Distribution, and other outputs of the project, after the project lifetime.

In order to ensure that the exploitation described in the sections above can continue, a sustainability plan which allows for the continued development, maintenance, innovation and support of the software is crucial.

### 4.1 Approaches to sustainability

The StratusLab project has developed a sustainability plan which focusses on the creating an open-source community to develop the StratusLab Distribution. Existing project partners will initially form the core of this community, but it is hoped that external parties will gradually become more involved. Several project partners are involved in EU or Nationally funded research projects which will continue to use and develop components of the StratusLab Distribution. Similarly, project partners who run existing infrastructures which now make use of StratusLab will continue to be involved, with several partners have committed to making unfunded contributions to the components in on which they rely.

#### 4.1.1 Continuation of the StratusLab collaboration

The founding members (CNRS, SixSq, GRNET and UCM) of the StratusLab project have previously collaborated in the context of the StratusLab initiative. This informal collaboration framework was created in November 2008 to evaluate the maturity of existing cloud and virtualization technologies and services to enhance production grid infrastructures, and to promote the benefits of virtualization and cloud for the grid community. All of the current project partners, including these founding members as well as TCD and TID, are committed to continuing this collaboration in some form after the end of the StratusLab project.

The scope of such a collaboration will be narrower than the current FP7 project, but the StratusLab distribution will be maintained as an open-source consortium.

StratusLab is involved in the ScienceSoft [7] initiative coordinated by EMI [2] which aims to assist scientific communities in finding software for scientific research. The initiative will host a repository of software, but this is unlikely to be in place by the end of the StratusLab project. Thus, while the StratusLab software

may eventually be hosted there along with software from other grid and cloud computing projects, ScienceSoft does not provide an immediate solution to the problem of sustaining the outputs of the StratusLab project.

The project has thus begun to migrate the StratusLab distribution code to GitHub [3], which offers free public repositories and associated tools used by over one million people worldwide to manage collaborative development projects.

The majority of current project members will continue to be involved to some extent and other contributors may be added in the future. A Contributor Licence Agreement will be drawn up to clarify the rights of contributors to the distribution, to ensure that IPR issues are adequately handled, and that the project direction and roadmap is clear.

## **4.1.2 Continuation of critical infrastructure**

Various organizations including the project partners, NGIs, collaborating projects and others have an incentive to maintain the software on which their critical infrastructure is (or will be) built.

A complete list of components and outputs of the StratusLab project is given below, along with the proposed sustainability plan, and the partners or external entities who have committed to continued development or service provision.

**Documentation and Website** Project deliverables are now available in the Hyper Article en Ligne (HAL) [4] open access repository and OpenAIRE [5] repository, making them available to a wider audience and ensuring that they are archived for posterity even if the StratusLab website should no longer be available.

LAL will continue to run the project website on a best-effort basis for some time after the project lifetime, however it is planned to archive the current content and migrate it to GitHub pages.

A new website will be created to serve as an ongoing hub for activities around the development of the open-source StratusLab distribution. There will be a change of focus on the website away from the project and towards the software.

All partners will continue to update documentation, but insofar as possible, this will no longer be hosted centrally on the website, but bundled with the software components.

**Marketplace Service** EGI is currently evaluating the use of the StratusLab Marketplace as part of its Federated Clouds Task Force. EGI has thus installed its own version of the Marketplace which is available to the EGI community. TCD is also committed to running an instance of the Marketplace service for the foreseeable future, and going forward, they may be involved in provision of the EGI Marketplace service in their role as the Irish NGI (Grid-Ireland). Other partners including CNRS will continue to use the Marketplace and have indicated a willingness to host it should TCD be unable to continue to provide the service.

**Appliance Repository** The Marketplace and persistent disk service mean that the appliance repository as implemented at the beginning of the project is now largely obsolete. Before the end of the project any appliances remaining in the

appliance repository will be migrated so that this service will not be required.

**VM Images** LAL will continue to maintain base images for the various operating systems supported at present. It is expected that user communities will take over the maintenance of the majority of virtual appliances, for example, EGI would maintain the UMD Grid images, IGE will maintain the Globus images while IBCP will continue to maintain the bioinformatics images for its user communities.

**Build and Test Tooling** There is limited interest among project partners in continuing to maintain the entire build and test infrastructure, however a minimal version of this may be migrated to the cloud so that it can continue to be used to build and test the open source StratusLab distribution beyond the project lifetime. Alternatively, other tools such as the Travis CI [9] distributed build system, which integrates with GitHub, could be used.

**SlipStream Deployment Models** These will be available but not actively maintained.

**Reference cloud services** GRNET will continue to provide their public cloud service running StratusLab. LAL will also continue to run a cloud service for the foreseeable future. This service will be available to the general public subject to demand. IBCP will also continue to run a StratusLab cloud service, but this will be mainly for French bioinformaticians.

**Grid Site** The StratusLab distribution will be available to any EGI site wishing to deploy a grid site on top of a StratusLab cloud. GRNET will also continue to run a grid site on StratusLab, the administration of which will be taken over by the Greek NGI.

### **4.1.3 Software**

The StratusLab distribution, the software produced by the StratusLab project, is the main output of the project. It is important to ensure that this software can continue to be developed and maintained with regular releases after the end of the project. As described in Section 4.1.1 the StratusLab code will be migrated to GitHub and will continue to be developed as part of an open-source project.

**Marketplace** Most of the project partners intend to continue using the StratusLab Marketplace and therefore will continue to contribute to its development. EGI are also investigating the use of the Marketplace and they appear to be willing to contribute to maintenance.

**Persistent Storage** SixSq have a number of commercial applications which use the StratusLab persistent storage and so will continue to maintain and develop this service. Other partners are also using this service and will continue to maintain it.

**Network Manager** The network management functionality is implemented as part of OpenNebula and will continue to be maintained by UCM. In addition, there is the possibility of further development in collaboration with the Mantychore project which is interested in using the StratusLab distribution as an enabling

technology for its community controlled virtual network services.

**Authentication proxy** LAL is committed to maintaining the authentication proxy with the possibility of further development to integrate it with tools such as the persistent storage or OpenNebula's SunStone interfaces.

**Service manager (Claudia)** TID will continue to develop this component and it will be used in the context of the 4CaaS project in which TID is a participant.

**OpenNebula** This is a pre-existing product developed by partner UCM; they will continue to develop and sustain it after the project lifetime.

**Stratuslab OpenNebula customisations** Some of the customisations for OpenNebula developed as part of the StratusLab project will be migrated into the OpenNebula repository and maintained by UCM going forward. An activity to identify which customisations will become part of OpenNebula is under way. Other components will be maintained by various project partners who are making use of them as part of the open-source StratusLab distribution, and these may also become part of the OpenNebula Ecosystem [6] which is a community portal for third party developers creating tools and extensions that complement the functionality provided by OpenNebula.

**Registration application** LAL intends to continue to maintain the registration application, with possible further development to make it more generic.

**Web Monitor Dashboard** It has been agreed not to further develop the Web Monitor Dashboard as OpenNebula SunStone now works with StratusLab deployments and provides much of the same functionality. The code will be frozen and made available in a GitHub repository, but will not be further developed or maintained.

**Quattor installation** CNRS is using the Quattor installation and will continue to update the Quattor profiles. In the longer term, it is intended to migrate these to the Quattor Working Group so that they are available to the rest of the Quattor community.

**Manual installation** The manual installation tools are used by SixSq as part of their commercial offerings based on StratusLab, and thus these will be maintained by SixSq going forward.

**Command Line clients** SixSq has committed to be the lead developer going forward on the command line interface component of the StratusLab distribution. Other partners will contribute to particular parts of the client tools, for example, GRNET intend to continue to develop the client tools related to automatic provisioning of clusters in the cloud, while TCD will continue to develop the Marketplace client tools.

**Monitoring** The Claudia KPI monitoring will be used by the 4CaaS project and development and maintenance will continue as part of that project.

**Accounting** The StratusLab accounting is largely part of OpenNebula and UCM will continue to maintain this functionality.

**Port Translation** IBCP will continue the development of this component.

**Hudson cloud adaptor for StratusLab** LAL intend to maintain this component provided it continues to be used going forward.

#### **4.1.4 Future research opportunities**

The project results will present opportunities for future research and development, which in turn will promote the sustainability of the project components.

Possible areas of future evolution include:

- Scheduling and advanced placement heuristics
- Messaging service for extensibility and scalability
- Scalable storage integration
- Virtual machine translation service
- Application deployment in the cloud
- Bringing computation to the data

The possibility of future research on a solid basis will appeal to academic and other research organizations, including the existing project consortium partners.

In the EGI model, appliance repositories will be widely deployed by virtual organizations using a variety of storage technology: with this in mind future work could investigate accessing appliance images stored in grid storage systems such as the Logical File Catalogue.

FP7 projects in which the StratusLab partners are involved, such as 4CaaSt and Mantychore, will continue research in some of these areas. Other research projects, such as TCD's work on virtualized GP-GPU grid worker nodes are also using the StratusLab outputs for future research.

Other entities may also be interested in the use of the StratusLab Distribution in their research, and the dissemination activities of WP3 have attempted to broadly disseminate the results of the project within the research community and beyond. The dissemination activities of the project have been described in [12], [13] and [14].

## **4.2 Paths to sustainability**

In Deliverable D3.3 a number of possible paths to sustainability were outlined, including public funding, private funding and community contributions. The sustainability activities detailed in this document encompass all three of these paths.

### 4.2.1 Public Funding

Public funding has been secured to continue the development of some components, for example, the Claudia Service Manager and Monitoring Systems which are to become part of the 4CaaS FP7 project of which TID is a member. Similarly, the EGI project is evaluating use of the Marketplace and TCD is hopeful that they can continue development of the Marketplace as part of their EGI activities.

GRNET has secured national funds to develop a comprehensive cloud solution for academic users, and while this will not be based on the StratusLab distribution, some components as well as know-how and expertise produced by the StratusLab project are likely to be reused.

### 4.2.2 Private funding

Project partners SixSq have been very successful in attracting private funding for integration of the StratusLab Distribution into new and existing business lines, giving them a revenue stream which allows them to commit to future development of several of the StratusLab components.

SixSq predicts that its business pipeline from SlipStream service and product will come in significant proportion from deploying private services inside customers' infrastructure. Since SlipStream targets StratusLab as its preferred private cloud solution, in turn, SixSq will be investing some of this revenue in the maintenance and evolution of the StratusLab solution.

As mentioned above, UCM offers value-added services around OpenNebula through the University Office of Technology Transfer. This funding is used to maintain and evolve the OpenNebula project and other StratusLab components which are now being integrated into the standard OpenNebula distribution.

Finally, partner Telefónica I+D is providing funding in the Global Cloud Initiative for developing the ideas about the multi-tier service management and scalability demonstrated by the Claudia framework.

### 4.2.3 Community contributions

It is envisaged that 'large users' may engage with the StratusLab development community and invest effort into the distribution.

Several partners have also pledged to contribute unfunded efforts towards maintenance of the project results. For instance, TCD is likely to make significant use of StratusLab software in future. In the case where dedicated funded effort for development is not available, TCD would still expect to contribute in the form of bug reports, patches and improvements as part of the StratusLab open source community.

Other user communities may contribute in the future and the project's **open source plan** will provide such communities with a mechanism for participation going forward.



## 4.3 Summary

The project has concrete plans in place for sustainability after the project lifetime, to include

- Continuation of critical infrastructure
- Continued development of the software components
  - as part of an open source community
  - as part of FP7 funded projects such as 4CaaSt and Mantychore
  - by existing infrastructures who are using the components, for example, EGI for the StratusLab Marketplace and IGE for the Globus Virtual Appliances
  - through commercial activities by partners SixSq, TID and UCM
- Future research continuing the themes of the StratusLab project, or using its outputs

The outputs of the project along with the specific plans to sustain them are listed in Table 4.1.

**Table 4.1: Sustainability Plans**

Output	To be Sustained?	Partner	Plan
Documentation and Website	Yes	LAL	GitHub pages, open access repositories
Marketplace Service	Yes	TCD, CNRS	TCD will continue to run the Marketplace, perhaps as part of EGI. EGI is also running its own Marketplace. CNRS may also run a federated Marketplace instance
Appliance Repository	No		
VM Images	Yes	CNRS, external parties	CNRS LAL will maintain base images, CNRS IBCP will maintain bioinformatics images, others will be taken over by external projects
Build and Test Tooling	No		Minimal version only will be maintained
SlipStream Deployment Models	No		These will be available but not developed further
Reference cloud services	Yes	GRNET, IBCP	GRNET and LAL will continue to run public cloud services based on StratusLab, IBCP will run an instance for the French bioinformatics community
Grid Site	Yes	GRNET	GRNET will continue to run the StratusLab grid site administration of which will be taken over by the Greek NGI
Marketplace	Yes	TCD, external parties	TCD will continue as lead developer on the Marketplace, but most of the project partners as well as a number of external entities such as EGI intend to use it and are willing to contribute to its future development and maintenance
Persistent storage	Yes	SixSq	SixSq will continue to maintain this component, and other partners may contribute
Network manager	Yes	UCM	This will be maintained as part of OpenNebula
Authentication proxy	Yes	CNRS	LAL will continue to maintain this component
Service manager (Claudia)	Yes	TID	Claudia will be used by other projects and TID will continue to develop and maintain it
			Continued on next page

Table 4.1 – continued from previous page

Output	To be Sustained?	Partner	Plan
OpenNebula customisations	Yes	UCM	UCM will take over development and maintenance of most of the StratusLab OpenNebula customisations and enhancements
Registration application	Yes	CNRS	LAL will continue to maintain this
Web Monitor Dashboard	No		The Web Monitor Dashboard code will be available, but not further developed by the project partners
Quattor installation	Yes	CNRS	This will be maintained and fed into the Quattor Working Group
Manual installation	Yes	SixSq	This is used by SixSq and they will continue to develop it
Command Line clients	Yes	All	SixSq will assume overall responsibility for the command line clients, but all partners will continue to develop them
Monitoring	Yes	TID	TID will maintain and develop the Claudia KPI Monitoring
Accounting	Yes	UCM	UCM will maintain the StratusLab Accounting as part of OpenNebula
Port Translation	Yes	CNRS	IBCP will maintain and develop this component
Hudson cloud adaptor for StratusLab	Yes	CNRS	LAL are currently using this component and will continue to maintain it for the time being

## 5 Conclusions

This document has summarised the current status of exploitation of the StratusLab Distribution. Project partners and external entities are actively using the outputs of the project in a variety of ways, including:

- Commercial integration and support, by project partners including SMEs and large corporations.
- e-Infrastructure deployment for cloud and grid infrastructures
- National infrastructures that are migrating towards a cloud model
- OpenNebula, as a means to bring StratusLab developments to all its users
- Collaborating projects including EDGI, EGI, Mantychore and 4CaaSt FP7 projects
- Training and e-Learning, and future cloud research

The sustainability plans beyond the project lifetime are also outlined. The project has concrete plans in place to ensure the sustainability of the project's outputs.

Partners are committed to continuing to run the critical infrastructure such as the reference infrastructure, the grid site running on a StratusLab cloud and the Marketplace.

Plans are in place to continue the development and maintenance of most of the software components. StratusLab partners will continue developing various components in the context of other FP7 or nationally-funded research projects, and as part of an open-source StratusLab community. Other components will be taken over, or contributed to, by collaborating projects, for example, EGI will contribute to the Marketplace.

The commercial exploitation efforts of the project have also resulted in several new avenues for sustainability with private funding available to continue development of components which now form part of commercial product offerings.

Finally, future research opportunities still exist and these may lead to further development of the StratusLab Distribution by the project partners or others.

## Glossary

APEL	Accounting Processor for Event Logs (EGI accounting tool)
Appliance	Virtual machine containing preconfigured software or services
CDMI	Cloud Data Management Interface (from SNIA)
CE	Computing Element in EGI
DCI	Distributed Computing Infrastructure
DMTF	Distributed Management Task Force
EGEE	Enabling Grids for E-sciencE
EGI	European Grid Infrastructure
EGI-TF	EGI Technical Forum
GPFS	General Parallel File System by IBM
Hybrid Cloud	Cloud infrastructure that federates resources between organizations
IaaS	Infrastructure as a Service
iSGTW	International Science Grid This Week
KPI	Key Performance Indicator
LB	Load Balancer
LRMS	Local Resource Management System
MoU	Memorandum of Understanding
NFS	Network File System
NGI	National Grid Initiative
OCCI	Open Cloud Computing Interface
OVF	Open Virtualization Format
Public Cloud	Cloud infrastructure accessible to people outside of the provider's organization
Private Cloud	Cloud infrastructure accessible only to the provider's users
SE	Storage Element in EGI
TCloud	Cloud API based on vCloud API from VMware
VM	Virtual Machine
VO	Virtual Organization
VOBOX	Grid element that permits VO-specific service to run at a resource center
Worker Node	Grid node on which jobs are executed
XMLRPC	XML-based Remote Procedure Call
YAIM	YAIM Ain't an Installation Manager (configuration utility for EGI)

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